Supply chains : ago-antagonistic systems through co-opetition game theory lens

I. Zouaghi, A. Spalanzani

Centre d'Etudes et de Recherches Appliquées à la Gestion_ U.M.R. C.N.R.S. 5820
www.cerag.org

CAHIER DE RECHERCHE n°2009-13 E5

Supply chains : ago-antagonistic systems through co-opetition game theory lens

ZOUAGHI Iskander
SPALANZANI Alain

Unité Mixte de Recherche CNRS / Université Pierre Mendès France Grenoble 2
150 rue de la Chimie – BP 47 – 38040 GRENOBLE cedex 9
Tél. : 04 76 63 53 81 Fax : 04 76 54 60 68

SUPPLY CHAINS: AGO-ANTAGONISTIC SYSTEMS THROUGH CO-OPETITION GAME THEORY LENS

Iskander Zouaghi [1] and Alain Spalanzani [2]

Abstract *— Supply chain configurations, as hybrid governance structures, allow companies to be sufficiently integrated while keeping a certain level of flexibility. This enables them, on one hand, to converge towards common interests through the development of cooperation; and on the other hand, to diverge on their own interests by remaining in competition. This dynamics generates an ago-antagonistic system where both of these two concepts, namely cooperation and competition, simultaneously drive the supply chain. In the present article, this system is analyzed by using the co-opetition game theory developed by Brandenburger and Nalebuff (1996) in order to highlight the importance of such an apprehension of the supply chain approach.*

Keywords *— Supply chain, cooperation, competition, ago-antagonistic approach, co-opetition game theory.*

INTRODUCTION

These last years, companies has been evolving in a complex environment characterized by open markets, globalization of supply, increasing demand but also by consumers who are becoming increasingly hard to please in terms of product quality and service. This has prompted them to focus on their core competencies [1]-[2], by outsourcing non-generating value activities, yielding a growing number of small and medium companies. This densification has resulted in more complex flows (material, informational and financial), increasing, therefore, uncertainty about the environment. This has resulted in an increase in the variability of demand, reducing, consequently, visibility for companies [3], but also and above all increasing difficulty for rationalizing flows throughout the value system in the terms of Porter [4]. To cope with such constraints, firms have adopted new business models and new organizational configurations around the notion of networks. These were achieved by the advent of 'supply chains', which, in the terms of Miles and Snow [5], represent central organizing units in nowadays' industries.

Supply chain is a hierarchical, dynamic and processual network, made up of a set of companies (from the first supplier to the end customer), linked by upstream and downstream flows (physical, informational, financial and knowledge) and different level relationships, established in order to satisfy the customer through better coordination and integration, but also greater flexibility and responsiveness. The supply chains can be presented as inevitable phenomena arising from a need for coordination and flexibility among a number of companies. In this sense, supply chains exist, whether managed or not [6].

Currently, cooperative paradigm dominates supply chain management (SCM) approach. In this paradigm, SCM is based on a systemic approach. It identifies the supply chain as a whole which is greater than the sum of its parts, not as a fragmented set of entities, against which each one acts for its own [7]. This approach is characterized by a certain number of concepts such as integration, coordination, collaboration, information sharing, common interests and mutual competitive advantage. However, when we speak about integration in SCM, we do not mean vertical one. Entities in the supply chain are autonomous and the supply chain itself is a dynamic network with actors that appear and disappear over time.

Another paradigm focuses on the need of the development of competition between actors. In this way, based respectively on works of [8]-[9]-[10]-[11], Lado et al. [12] state that competition engenders economic efficiencies by enabling companies to optimally allocate scarce resources, providing the impetus for innovation and entrepreneurship, and reducing transaction costs between them. Furthermore, companies that constitute the supply chain are partially characterized by rationality and self interests. All this allow the supply

[1] Iskander Zouaghi, Pierre Mendès-France University, Center for Study and Research in Applied Management - CERAG, Grenoble, France, iskander.zouaghi@upmf-grenoble.fr
[2] Alain Spalanzani, Pierre Mendès-France University, Center for Study and Research in Applied Management - CERAG, Grenoble, France, alain.spalanzani@upmf-grenoble.fr

chain to be agile and flexible. These conditions are necessary to cope with a disruptive and unstable environment, and provide the possibility for change and innovation.

In nowadays intellectual conception, both of these two paradigms become necessary and complementary at the same time. They are jointed under a third perspective which is a co-opetition one. In this article, we focus on this approach within supply chains, to underline the importance of both of these concepts that are paradoxical and complementary at the same time, and which constitute its principal motive. Such an approach will be analyzed and justified through ago-antagonistic systems theory [13], which study phenomena associating co-operation and conflict behaviors. After that and it's the second aim of the article, we will mobilize game theory, and especially co-opetition game theory [14], to analyses supply chain as an ago-antagonistic system (AAS), but also to make a theoretical connection between these two theories.

THE NATURE OF SUPPLY CHAINS AND THEIR MANAGEMENT

The Nature of Supply Chains: A Hybrid Governance Structure

The structural typology of governance most used is that proposed by the proponents of the Transaction Costs Theory (TCT), initiated by Coase [15] and developed by Williamson [11]. Broadly speaking, the transaction costs are the sum of three fundamental features of exchange between economic actors. These elements are the costs of coordination between different actors, risks relating to operations and risks of opportunism [16]. Clemons et al. [16] state that coordination costs reflect the costs of information exchange (product, demand, inventory, production capacity ...), those related to the integration of this information in the decision-making process, and costs related to delays due to communication problems. Risks relating to operations are risks of misinformation or voluntary information withholding. Finally, the risks of opportunism include risks relating to the lack of bargaining power or its loss. From this basic principle, companies can choose from two forms of governance: an internalization of their activities leading to hierarchy governance, or outsourcing some of them by a market one. The first alternative mainly revolves around integration mechanisms, such as monitoring, procedures or authority. While the second alternative, is mainly a sub-contract option.

Though, are to highlight structures that do not have a typical form of governance, those which are midway between market and hierarchy. These structures are mainly characterized by network configurations that have a particular form of organization. Supply chain is a particular kind of network. It is a hierarchical, dynamic and processual network that require both cooperation and competition efforts. This hybrid form of governance structure, integrate advantages of both other forms of governance, namely the market and the hierarchy, reducing at the same time, their disadvantages. In other words, companies remain legally independent, retaining their identity, their culture and their capabilities, and also a structural flexibility, while being in close collaboration with other companies in pursuing their common goals.

Managing the Supply Chain

Put simply, SCM is management of material, financial and informational flows from the first supplier to end customer. For Mentzer et al. [11] (p.18), '*Supply chain management is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole*'. Cooper et al. [17] define it as an integrative philosophy to manage the total flow of a distribution channel from supplier to the ultimate user. The principal objective of SCM is to maximize the value created, not just for one company but for the whole supply chain, including the end customer. Therefore, supply chain process integration and re-engineering should concern efficiency and effectiveness of all processes across its members [18].

The issue of integrating the supply chain is not as obvious as some think. The integration of a supply chain is not automatic. For Lambert and Cooper [19], it is necessary, first, to identify activities and key members to integrate, while recognizing that an excessive integration could be detrimental to the performance of the supply chain. Then, since the drivers for integration are situational and different from process link to other, the levels of integration differ from link to link, and also vary over time. Finally, the integration of the supply chain also depends on certain organizational factors such as: trust, commitment, interdependence, organizational compatibility, vision, leadership and top management support [11].

Some researchers stress on the necessary balance between the practice of a lean management and an agile one [20]-[21]-[22]. Naylor et al. [20] state that leanness means developing a value stream to eliminate all waste, including time, and to ensure a level schedule. While agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile marketplace. Fabbe-Costes [22] affirms that on one hand, the practice of lean management helps integrating the supply chain by the adaptation of all its actors, to ensure cost reduction and improved service level in operational process logic. On the other hand, agile management generate flexibility (static and dynamic) and adaptability of processes, organizations and supply chains to cope with instability, turbulence, uncertainty and risks in the environment. Likewise, agility has been defined as the ability of an organization to quickly respond to changes in demand, both in terms of volume and variety [23].

In supply chain management, integration and outsourcing are both important. This has lead academics and professionals to combine lean and agile approaches, producing the concept of 'leagile' management [20]. Leagile is adopted by positioning the decoupling point so as to best suit the need for responding to a volatile demand downstream yet providing level scheduling upstream from the market place [24]. The decoupling point is the point that separates activities based on customer orders from those founded on planning and forecasting [25].

THE SUPPLY CHAIN: AN AGO-ANTAGONISTIC SYSTEM

Ago-antagonistic Systems Approach

At its birth, the general systems theory has come to challenge conventional physics and biology, principally by integrating different sciences (natural and social) in the same paradigmatic framework [26]. This theory deals about the structure and dynamics of systems, whatever its type: physical, biological or social. A system is conceptualized as an integrated whole, which is more than the sum of its parts. It is composed of a set of interacting and interdependent elements. The notions of complexity, self-organization, homeostasis, teleonomy, immanentism and so on, represent the foundation of the general systems theory. Even if this theory claims to conceptual flexibility, its interaction with some sciences made it relatively rigid. However, came the theory of Ago-Antagonistic Systems (AAS), which is one of its branches, permitted greater flexibility in apprehension of a lot of phenomena.

AAS approach combines concepts that were usually opposed. The notion 'ago-antagonistic' is composed of the term 'antagonistic', which is employed to indicate the conflictuality of the couple's poles (opposite or only different), and 'agonistic', means that conflict has positive and non-destructive effects [27]. In fact, it represents the association of cooperation and conflict in the same phenomenon and implicates bipolar strategies [28]. For example, it combines complexity and simplicity, self-organization and hetero-organization, homeostasis and homeorhetic, immanentism and transcendence in the same systemic framework.

According to Bernard-Weil [29][27], this approach is identified through eight (8) principal characteristics. The first one is about the definition of an ago-antagonistic couple, whose poles have, in one hand, opposite actions on a part of the receiver of these forces; and on the other hand actions in the same direction on the other part (or on another receiver). So the ago-antagonistic model is composed of three major things: a couple of forces (x and y), a regulator and a receiver. The second characteristic is that the AAS is a dissipative system in the sense of Prigogine's works[3]. This is defined by the notion of equilibration against a standard. So mathematically, AAS has two equilibrium states: a physiological equilibrium (if the standards are respected) or a pathological equilibrium (the model runs on poor followed standards). It does mean that the equilibration can be asymptotic, oscillating around the equilibrium point or chaotic. The third characteristic deals with the fact that ago-antagonistic combination of elementary models, which are also ago-antagonistic, produces an ago-antagonistic network. Primary, the network structure dialectises hierarchy and autonomy. Secondly, it explains the fact that an action on one part of the network can rebalance the whole network. The forth one is the constituent division, which means that one pole acts for its own interest and at the same time for the common one. The fifth feature is that the AAS integrate dichotomies, namely a series of properties normally incompatible with each other, like open and closed, synchronic and diachronic, simple and complex, hierarchical and autonomous, realistic and conventional, and so on. The sixth one presents the fact that AAS is relative to the notion of pathological homeostasis, or autonomy; that allows understanding what strategies, yet

[3] In 1977, Ilya Prigogine was Nobel Prize in Chemistry Laureate for his works on thermodynamics, which lead to the discovery of dissipative structures.

unusual, ago-antagonist systemics may lead. The penultimate characteristics deals with wrong ago-antagonistic couples, like imbalance and balance, good and evil, and so forth, despite their semantic opposition. The last feature is somewhat difficult to grasp and deals about the complicated apprehension of the meta-model of the ago-antagonistic model. Every model, even those claiming to universality, requires a meta-model [30], and the one of ago-antagonistic model is not yet identified.

To better apprehend this approach, we present the MMRAAC (Mathematical Model for the Regulation of Agonistic Antagonistic Couples) developed by Bernard-Weil [28]:

First, we have to specify the fact that two conditions allow a normal functioning, that is maintained by a homeostatic homeorhetic regulation are:

$$\begin{cases} x - y = c_1 \\ x + y = c_2 \end{cases}$$

Knowing that: (x, y) represent a couple of ago-antagonistic features, c_1 is a constant (generally: $c_1 = 0$) characterizing the antagonistic equilibrium, and c_2 is a constant (or a time relative variable) characterizing agonistic equilibrium. We have:

$$\begin{aligned} \dot{x} &= \sum_i k_i (u+r)^i + \sum_i c_i (v+s)^i, \\ \dot{y} &= \sum_i k'_i (u+r)^i + \sum_i c'_i (v+s)^i, \\ \dot{X} &= \sum_i k_{i+4} (u+r)^i + \sum_i c_{i+4} (v+s)^i + \Lambda_1, \\ \dot{Y} &= \sum_i k'_{i+4} (u+r)^i + \sum_i c'_{i+4} (v+s)^i + \Lambda_2, \end{aligned} \qquad (1)$$

Wherein

- $\Lambda_1 = \sum_i \lambda_j (X - \bar{X})^j, \qquad \Lambda_2 = \sum_i \lambda'_j \left(Y - \bar{Y}\right)^j; \quad i = 1,2,3, \qquad j = 1,2,3.$

  Λ_1, Λ_2 : penalty function that permit to keep away from the drift of the limit-cycle of dimension 4 (x, y, X, Y)
- $x(t)$, $y(t)$: state variables ; $X(t)$, $Y(t)$: control variables ; k_i, c_i, m, n: constant parameters or variable in relation to time ; $g(t)$: a synchronizer ; $p(t)$, $q(t)$: respectively antagonistic and agonistic forces.
- $u(t) = x(t) - y(t) + n + p(t);$ $\quad r(t) = X(t) - Y(t);$ $\quad v(t) = x(t) + y(t) - m + g(t) + q(t);$ $s(t) = X(t) + Y(t)$.

Supply Chain: An Ago-antagonistic System

When we analyze supply chains through AAS theory, we find that it has most of the characteristics presented above. The first characteristic was about the definition of ago-antagonistic couples. The study of supply chain strategies allowed us to identify some ago-antagonistic couples, like lean strategy versus agile strategy, integration versus outsourcing or hierarchy versus market strategy, reactive versus proactive strategy and cooperative versus competitive strategy.

The first one deals about leanness and agility. We saw earlier that these two strategic poles are conflictual, but their conflictuality has positive and non-destructive effects. Integrating leanness and agility gives us a leagility which represent a bipolar strategy. It permits to integrate the fact of having a level schedule by eliminating non-value added time, and at the same time best suit fluctuating demand by additional reduction of value-added time via production technology breakthroughs [20]-[31]. The second one is about integration versus outsourcing. When combined, these two contrasted strategies produce positive and non-destructive effect. In more specific terms, the search of taper integration by matching vertical integration and strategic outsourcing extends a company's product portfolio and success, which in turn allows the development of a competitive advantage and thus contribute to performance [32]. The third one deals about reactive versus proactive strategies that are differentiated in the literature, but their combination produce a positive and constructive effect. In this sense, Lambrechts et al. [33] state that proactive-reactive scheduling entail an assortment of a proactive strategy that insures a protected baseline schedule with a reactive strategy that allow to cope with the schedule infeasibilities caused by the distortions when the schedule is performed. The last ago-antagonistic couple is cooperative and competitive strategy. These two strategies are obviously heterogeneous; however they constitute a bipolar strategy that has constructive and positive effects. Indeed, for Dagnino and Padula [34], the coopetitive perspective come from the fact that both processes of value creation and value sharing occur, allowing the emergence of partially convergent interest structure where both competitive and cooperative strategies are performed at the same time and exactingly interrelated.

The second characteristic, which deals about the fact that an ago-antagonistic model is a dissipative system, is verified in supply chains. Actually, supply chain equilibrium is not static. In other words, there isn’t just a single equilibrium. There is a set of plausible equilibria [35], oscillating around a mean. The third one, dealing with ago-antagonistic network, is also verified by the fact that the supply chain is composed of ago-antagonistic couples that constitute an ago-antagonistic network. Furthermore, regulating action on one couple may rebalance the overall network. The fourth characteristic, concerning constituent division, is perceptible because of the hybridization of the supply chain structure. Actually, entities in supply chains are heterogeneous and have different objectives and constraints, but when it comes to performance of the whole chain, they become extremely inter-dependant in achieving such objectives as cost, quality or delay ones [36]. The fifth characteristic is about dichotomies. In supply chain as an AAS, couples represent dichotomies, like cooperation and competition that have a series of properties in principle incompatible with each other but they remain as in real systems that appear to comply with. In other terms, everyone seeks the benefit until it is moderated by system regulations. The sixth feature which treats about pathological autonomy or homeostasis is noticeable in a supply chain. Supply chain approach lead to strategies that were unusual in business strategies, and to which an ago-antagonist approach may also lead. The seventh characteristic deals about wrong or false ago-antagonistic couples. In a supply chain approach, we, generally, do not combine wrong ago-antagonistic couples to generate a bipolar strategy. We do use couples that even if they are contrasted, can have positive and constructive effects. The last characteristic is about the meta-model of the supply chain approach. We consider that the meta-model of the supply chain one is the network model. As long as we consider that the supply chain is a specific type of network, network theory remains the meta-model of the supply chain approach.

Finally, when we analyze these characteristics, we find that the supply chain is an ago-antagonistic system. Furthermore, we can say that this concept derives its strength from the fact that the approach leads to the implementation of bipolar strategies, known in other paradigms as opposing strategies.

SUPPLY CHAIN THROUGH CO-OPETITION GAME THEORY LENS

Co-opetition Game Theory

Game theory represents an important tool for the apprehension of player’s behaviors in strategic situations. It deals with a lot of kinds of games such as symmetric and asymmetric games, zero-sum and non-zero-sum games, simultaneous and sequential games, perfect information and imperfect information games, discrete and continuous games, one-player and multi-player games and cooperative or non-cooperative games. In this point, we focus our interest more on this last type of games, which are cooperative and non-cooperative games.

Cooperative games are games in which players can make binding commitments before choosing their strategies, whereas in non-cooperative games they don’t. The concept of non-cooperative game theory may, wrongly, mean that there is no place for cooperation, and the concept of cooperative game theory might also mean that conflict or competition does not exist [37]. If we deepen a little more the typology, we can have cooperative games with conflict and cooperative games without conflict, and also non-cooperative games with conflict and non-cooperative games without conflict [38]. Until the end of the 90s, business strategies were analyzed compared to a single type of game. However, in the second half of 90s, complex organizational structures have been multiplied, making strategic behaviors more problematic.

In 1995 and 1996, Adam M. Brandenburger from Harvard Business School and Barry J. Nalebuff from Yale School of Management have proposed an original and more realistic concept that was conceptualized ‘co-opetition’, joining two opposite strategic behaviors, namely cooperation and competition. Their approach is a sort of vulgarization of the game theory, which is not as easy as it may seem, and its application to business concerns. For Brandenburger and Nalebuff [14]-[39], co-opetition game theory is a theory of value, from which companies can create value by cooperation process, and at the same time capture value by competition one. So, both processes are important for companies. They state principally that in business, it's not like in other games such as sport games or others games where there is always a winner and a loser (or no winner and no loser). In business, all parts of the game can win or lose. In this way, Lado et al. [12] develop a model which is closed to that of Brandenburger and Nalebuff [14]. They call it 'syncretic model of rent-seeking strategic behavior'. This model allows understanding that high collaboration and competition are required to reach the syncretic rent-seeking behavior, which is a simultaneous pursuit of both competitive and cooperative strategies. However, Armstrong [40] states that the approach of Brandenburger and Nalebuff [14] is not really new, even if words are new. He added that the adoption of the game theory to business games and the combination of such strategies in the way they have done remain its strength.

Co-opetition in a Supply Chain as an Ago-antagonistic System

As we have seen above, cooperation and competition represent an ago-antagonistic couple in the supply chain, since on one hand they are viewed as a paradox, and on the other hand this paradoxical combination has positive and non-destructive effects. Co-opetition is defined as a process in which firms simultaneously compete in some areas and cooperate in others [41]. In supply chains, both cooperation and competition are important, and two logics are necessary. The first one is a transactional logic, which is generally characterized by competition behaviors, and the second one is relational, and is characterized commonly by cooperation strategies.

In a supply chain, firms search for common benefits by pooling complimentary resources, skills, and capabilities [12]. Hall and Potts [42] show that cooperation between a producer and its supplier may reduce the total cost, which depends on their scheduling objectives. However, benefits generated by cooperation must be fairly distributed among members, otherwise regulations and adjustments are needed to rebalance the whole chain [43]. This added to the fact that relationships between companies entail a complex interaction between ex-ante cooperation to mutually create value and ex-post self-interested bargaining to capture value [44]. So we can understand from this that there is always a part of competition in a given relationship.

Cooperation and competition coexist ago-antagonistically in a supply chain. The fact that the supply chain represents a dynamic network, made it more exposed to variations and instabilities giving rise to conflicts, or opportunistic behaviors, because of the uncertainty and ambiguity of certain situations. This generates paradoxically a certain need for cooperation and collaboration. In fact, these two forces, namely cooperation and competition, act ago-antagonistically on the supply chain members. This led us to say that coopetition strategies represent ago-antagonistic solutions for managing the supply chain.

If we consider that, in a supply chain, the two ago-antagonistic conditions (1) and (2) seen above ($x - y = c_1$ and $x + y = c_2$; x : cooperation, y : competition) are satisfied, the supply chain is characterized by a normal dynamical equilibrium of x and y maintained by one of the known methods of regulations. This regulation can be performed by traditional methods, namely passive regulation methods (buffer inventory, service rate and financial models) or active regulation ones (option value, search of internal flexibility); or by modern methods of uncertainty regulation, namely outsourcing and the development of external flexibility, or external risk management through a collaborative mode of exchange [45].

Otherwise, if the supply chain displays a deviation from the 'average', caused by a force that gives rise to an abnormal fluctuation, the supply chain may stabilize, by an altered regulation, in a pathological dynamical equilibrium between x and y . In this situation we have either $x - y \neq c_1$ or $x + y \neq c_1$, or both of them. Here, to insure a new homeostatic homeorhetic rule, we bring the supply chain to a new critical point with $x + X - y - Y = c_1$, $x + X + y + Y = c_2$.

So in a chaotic dynamics, the MMRAAC becomes as follows [28]:

$$\dot{x}_i = \sum_j k_{ij}(u_i + r_i)^j + \sum_j c_{ij}(v_i + s_i)^j + \sum_j \bar{k}_{ij} \sum_j (u_i + r_i)^j + \sum_j \bar{c}_{ij} \sum_j (v_i + s_i)^j,$$

$$\dot{y}_i = \sum_j k'_{ij}(u_i + r_i)^j + \sum_j c'_{ij}(v_i + s_i)^j + \sum_j \bar{k}'_{ij} \sum_j (u_i + r_i)^j + \sum_j \bar{c}'_{ij} \sum_j (v_i + s_i)^j, \quad (2)$$

$$\dot{X}_i = \sum_j \tilde{k}_{ij}(u_i + r_i)^j + \sum_j \tilde{c}_{ij}(v_i + s_i)^j + \sum_j \tilde{k}_{ij} \sum_j (u_i + r_i)^j + \sum_j \tilde{c}_{ij} \sum_j (v_i + s_i)^j + \Lambda_1,$$

$$\dot{Y}_i = \sum_j \tilde{k}'_{ij}(u_i + r_i)^j + \sum_j \tilde{c}'_{ij}(v_i + s_i)^j + \sum_j \tilde{k}'_{ij} \sum_j (u_i + r_i)^j + \sum_j \tilde{c}'_{ij} \sum_j (v_i + s_i)^j + \Lambda_2.$$

Wherein

$$\Lambda_1 = \sum_j \lambda_{ij}\left(X_i - \overline{X_i}\right)^j, \qquad \Lambda_2 = \sum_j \lambda'_{ij}\left(Y_i - \overline{Y_i}\right)^j; \quad i = 1,2 \ldots m \quad j = 1,2 \ldots n$$

$$u_i = \sum_j (x_i - y_i), \qquad v_i = \sum_j (x_i + y_i - m_i), \qquad r_i = X_p - Y_p, \qquad s_i = X_p + Y_p,$$

Evidence of Co-opetition from Supply Chain Management Literature

A lot of works have been done to materialize bipolar strategies adopted by organizations in different logistics and supply chain management fields. Concerning sourcing strategies, some companies adopt hybrid sourcing strategies, known as parallel sourcing strategies [49]. This kind of bilateral strategy integrates cooperation and competition in the same rational. It permits a company to establish cooperative relationships with each supplier, while maintaining competition between them [50]. In this way, Richardson [49] demonstrates, in a study of Japanese automobile industry using game theory, that parallel sourcing is better than sole sourcing depends on the sum of the setup costs for parallel source opposed to the lower trading and competitiveness costs resulting from higher supplier performance.

Likewise, as we saw above, leagile manufacturing strategies, integrating a lean and an agile vision are more and more adopted by companies, by shifting the decoupling point according to their objectives, capabilities and constraints. Naylor et al. [20] demonstrates that, in a PC manufacturing, companies definitely combine the two paradigms, using the decoupling point as a buffer between the variable demand for the paramount part of products and the level production schedule for some of the components. Qi et al. [51] support this argument by confirming that in some situations, these approaches can be combined together to enable a total supply chain strategy, which includes the best of both of them. But in this kind of strategy, game theory is not much used, and even less co-opetition game theory. However, we think that in this case, coopetition strategy can refer to leagile strategy. As Naylor et al. [20] state, leanness means developing a value stream to eliminate all waste, including time, and to ensure a level schedule. This requires close cooperation between the different members of the supply chain to ensure such a paradigm. On the other hand, agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile marketplace [20]. This is a strategy which is based more on a competition spirit and value-capturing within the chain. But we do believe that the coopetition game theory fits more cases where, for example, there is a supplier which manufactures the same component for two competitors. Here, companies cooperate on some of their manufacturing activities, while competing in others, such as marketing, sales, etc.

IT strategies can also be good examples. Chin [52] studied the chemical process industries in American companies. Coopetition strategies were principally characterized by the establishment of a kind of e-marketplaces, namely e-hub, to connect multiple buyers to multiple suppliers by linking their ERP (Enterprise Resource Planning) systems. This e-hub is an inter-organizational system that permits competing companies to cooperate within their supply chain. This ago-antagonistic strategy enhanced performance of a big number of supply chain members.

Concerning inventory, Cachon and Zipskin [53] studied competitive and cooperative inventory policies in a two-stage supply chain using game theory. They demonstrate that games have generally a unique Nash equilibrium that differs from the optimal solution. They conclude from this point that competition reduces efficiency. Moreover, they show that value of cooperation is context specific. They stipulate that in some settings competition increases total cost by only a fraction of a percent, whereas in other settings the cost increase is enormous. So companies have to find a consensus on how the total cost will be allocated, and this suggests coopetitive solution in which companies act both in cooperative and competitive way [54].

CONCLUSION

The principal aim of this article is a theoretical approximation of two major approaches in order to better apprehend the supply chain dynamics. The first approach belongs to the systemic nebula, but is a bit original. Known as ago-antagonistic system theory, it allows us to see that systems are subject to paradoxical forces, but that their combination produces a positive and non-destructive effect. The second approach is a game theoretical one, and combines cooperation and competition games, that are commonly two opposite strategic behaviors, into a coopetition ones. It integrates the fact that firms tend to create value (by cooperation) and capture value (by competition) in the same time. So, they behave in such way that they can simultaneously satisfy their own interests and the common interests of the supply chain.

These approaches are perfectly suited to the paradigmatic context of the supply chain. So, developing a common analytical framework seems quite fecund for further research. This will allow understanding a lot of supply chain phenomena, like those evoked above, by conceptualizing bipolar strategies as an ago-antagonistic solution for supply chain requirements and its member's behavior. The second one is the need of the development of a mathematical model of members' differentiated behavior based on MMRAAC. This non-linear differential equation model will permit approximately to predict members' behavior and strategy. Also, the integration of the concept of pathological equilibrium in a game theoretical framework opens a door to future conceptual exploration. This can be applied to the supply chain framework, after having distinguished its characteristics within an organized complexity or within a chaotic (or desorganized) one. Finally, the development of a common mathematical model between MMRAAC and the game theory allows a more detailed and quantifiable understanding of coopetition as an ago-antagonist concept within supply chains.

REFERENCES

[1] Hamel, G., and Prahalad C.K., 1990, "The core competence of the corporation", Harvard business review, 68, No 3, 79–91.

[2] Wernerfelt, B. 1984, "A resource-based view of the firm", Strategic management journal, 171–180.

[3] Forrester, J. W. 1958, "Industrial Dynamics: A Major Breakthrough for Decision Makers", Harvard Business Review, 36, No 4, 37-66.

[4] Porter, M.E., 1986, "Competition in Global Industries", Harvard Business School Press, 1.

[5] Miles, R.E., and Charles C.S., 2007, "Organization theory and supply chain management: An evolving research perspective", Journal of Operations Management, 25, No 2, 459-463.

[6] Mentzer, J.T., DeWitt, W., Keebler, J.S., Min, S., Nix, N.W., Smith, C.D. and Zacharia, Z.G., 2001, "Defining supply chain management", Journal of Business Logistics, 22, No 2, 1-25.

[7] Ellram, L. M. and Cooper, M.C., 1990, "Supply chain management, partnerships, and the shipper-third party relationship", International Journal of Logistics Management, 1, No 2, 1-10.

[8] Smith, A. 1937, "An Inquiry into the Nature and Causes of the Wealth of Nations", (1776). Methuen.

[9] Nelson, R.R., 1991, "Why do firms differ, and how does it matter?", Strategic management journal, 61–74.

[10] Schumpeter, J. A. 1934. "The theory of economic development", Springer.

[11] Williamson, O. E., 1979, "Transaction-cost economics: the governance of contractual relations", The journal of Law and Economics, 22, No 2, 233.

[12] Lado, A.A, Boyd, N.G. and Hanlon S.C., 1997, "Competition, cooperation, and the search for economic rents: a syncretic model", Academy of Management Review, 110–141.

[13] Bernard-Weil, E., 1988, "Précis de systémique ago-antagoniste: introduction aux stratégies bilatérales", L'interdisciplinaire.

[14] Brandenburger, A. M, and Nalebuff, B.J., 1996, "Co-Opetition: A revolution mindset that combines competition and cooperation: the game theory strategy that's changing the game of business", Bantam Dell.

[15] Coase, R. H., 1937, "The nature of the firm", Economica, 386–405.

[16] Clemons, E. K., Reddi, S. P. and Row, M.C., 1993, “The impact of information technology on the organization of economic activity: the "Move to the middle" hypothesis”, Journal of Management Information Systems, 10, No 2, 9-35.

[17] Cooper, M.C., Ellram, L.M. Gardner, J.T. and Hanks, A.M., 1997, Meshing multiple alliances, Journal of Business Logistics, 18, No 1, 67-89.

[18] Lambert, D.M., 2001, “Supply chain management: what does it involve”, Supply Chain and Logistics Journal, 4.

[19] Lambert, D.M. ans Cooper M.C., 2000, “Issues in Supply Chain Management”, Industrial Marketing Management, 29, No 1, 65-83.

[20] Naylor, J. B., Naim, M.M., and Berry D., 1999, “Leagility: integrating the lean and agile manufacturing paradigms in the total supply chain”, International Journal of Production Economics 62, No 1-2, 107-118.

[21] Christopher, M., Peck, H. and Towill, D., 2006, “A taxonomy for selecting global supply chain strategies”, The International Journal of Logistics Management, 17, No 2, 277-287.

[22] Fabbe-Costes, N., 2007, “La gestion de la chaîne logistique multi-acteurs : les dimensions organisationnelles d'une gestion lean et agile”, In La gestion de la chaîne logistique multi-acteur : perspective stratégique, Grenoble: PUG.

[23] Christopher, M., 2000, “The agile supply chain competing in volatile markets”, Industrial marketing management, 29, No 1, 37–44.

[24] Van Hoek, R.I., Harrison, A. and Christopher M., 2001, “Measuring agile capabilities in the supply chain”, International Journal of Operations and Production Management, 21, No 1/2, 126–147.

[25] Hoekstra, S., Romme, J. and Argelo, S.M., 1991, “Integral Logistic Structures: Developing Customer-Oriented Goods Flow”, Industrial Press, Inc.

[26] Von Bertalanffy, L., and Sutherland, J.W., 1974, “General systems theory: Foundations, developments, applications”, IEEE Transactions on Systems, Man and Cybernetics, 4, No 6, 592-592.

[27] Bernard-Weil, E., 2003, “Théorie et praxis des systèmes ago-antagonistes”, Res-Systemica, 3, No 1-2.

[28] Bernard-Weil, E., 2002, “Ago-antagonistic systems”, In Quantum mechanics, mathematics, cognition and action: proposals for a formalized epistemology, 325-348. Kluwer Academic Publishers.

[29] Bernard-Weil, E., 2002, “Approche des systèmes ago-antagonistes”, Techniques de l'ingénieur, L'Entreprise industrielle, No AG 1575: 1575–1575.

[30] Bernard-Weil, E., 1999, “La théorie des systèmes ago-antagonistes”, Le Débat(Paris. 1980), No 106, 106–120.

[31] Mason-Jones, R., Naylor, B. and Towill, D.R., 2000, “Lean, agile or leagile? Matching your supply chain to the marketplace”, International Journal of Production Research, 38, No 17, 4061–4070.

[32] Rothaermel, F.T, Hitt, M.A. and Jobe L.A., 2006, “Balancing vertical integration and strategic outsourcing: effects on product portfolio, product success, and firm performance”, Strategic Management Journal, 27, No 11, 1033–1056.

[33] Lambrechts, O., Demeulemeester, E. and Herroelen, W., 2008, “Proactive and reactive strategies for resource-constrained project scheduling with uncertain resource availabilities”, Journal of Scheduling, 11, No 2, 121–136.

[34] Dagnino, G. B, and Padula, G., 2002, “Coopetition strategy: a new kind of interfirm dynamics for value creation”, In Innovative Research in Management, European Academy of Management (EURAM), Second Annual Conference, Stockholm, May 9.

[35] Cachon, G. P, and Netessine, S., 2006, “Game theory in supply chain analysis”, Tutorials in Operations Research: Models, Methods, and Applications for Innovative Decision Making.

[36] Swaminathan, J. M, Smith, S.F. and Sadeh, N.M., 1998, “Modeling supply chain dynamics: A multiagent approach”, Decision Sciences, 29, No 3, 607–632.

[37] Marchi, E., Cohen, P.A. and Garcia-Cestona, M., 2009, “Cooperative game theory solution in an upstream-downstream relationship”, IMA Preprint Series.

[38] Rasmusen, E., 2006, “Games and Information: An Introduction to Game Theory”, 4 ed. Blackwell Publishing Ltd.

[39] Brandenburger, A. M, and Nalebuff, B.J., 1995, “The right game: use game theory to shape strategy”, Harvard Business Review, 73, 57–57.

[40] Armstrong, J.S., 1997, “Why can't a game be more like a business? A review of Co-opetition by Brandenburger and Nalebuff”, Journal of Marketing, 61, 92–95.

[41] Gee, E.P., 2000, “Co-opetition: the new market milieu”, Journal of healthcare management/American College of Healthcare Executives, 45, No 6, 359.

[42] Hall, N.G, and Potts, C.N., 2003, “Supply chain scheduling: Batching and delivery”, Operations Research, 566–584.

[43] Ballou, R. H, Gilbert, S.M. and Mukherjee, A., 2000, “New managerial challenges from supply chain opportunities”, Industrial Marketing Management, 29, No 1, 7–18.

[44] Ghosh, M., and John, G., 1999, “Governance value analysis and marketing strategy”, The Journal of Marketing, 131–145.

[45] Spalanzani, A. and Samuel, K.E., 2007, “Absorbing uncertainty within supply chains”, International Journal of Productivity and Quality Management, 2, No 4, 441–458.

[46] Carlton, D.W., Perloff, J.M. and Mazerolle, F., 1998, “Economie industrielle”, De Boeck Université.

[47] Zhang, F., 2006, “Competition, Cooperation, and Information Sharing in a Two-Echelon Assembly System”, Manufacturing & Service Operations Management, 8, No 3, 273-291.

[48] Subramani, M., 2004, “How do suppliers benefit from information technology use in supply chain relationships”, MIS Quarterly, 28, No 1, 45–73.

[49] Richardson, J., 1993, “Parallel Sourcing and Supplier Performance in the Japanese Automobile Industry”, Strategic Management Journal, 14, No 5, 339-350.

[50] Dubois, A. and Fredriksson, P., 2008, “Cooperating and competing in supply networks: Making sense of a triadic sourcing strategy”, Journal of Purchasing and Supply Management, 14, No 3, 170-179.

[51] Qi, F., Xuejun, X. and Zhiyong, G., 2007, “Research on Lean, Agile and Leagile Supply Chain”, International Conference in Wireless Communications, Networking and Mobile Computing, WiCom 2007, 4902–4905.

[52] Chin, K., 2001, “In the spirit of "coopetition"”, Chemical Engineering Progress. http://findarticles.com/p/articles/mi_qa5350/is_200105/ai_n21472701/pg_2/?tag=content;col1.

[53] Cachon, G. P. and Zipkin, P.H., 1999, “Competitive and cooperative inventory policies in a two-stage supply chain” Management science, 45, 936–953.

[54] Wong, H., Van Oudheusden, D. and Cattrysse, D., 2007, “Cost allocation in spare parts inventory pooling”, Transportation Research Part E: Logistics and Transportation Review, 43, No 4, 370-386.